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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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10/649,351

08/26/2003

Sang-Hyeob Lee

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EXAMINER

NGUYEN, HA T

ART UNIT

PAPER NUMBER

2812

DATE MAILED: 02/08/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 10/649,351	Applicant(s) LEE ET AL.	
	Examiner Ha T. Nguyen	Art Unit 2812	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-35 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-35 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☒ The drawing(s) filed on 26 August 2003 is/are: a) ☒ accepted or b) ☐ objected to by the Examiner.
 Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
 Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. ____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
- * See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413)
Paper No(s)/Mail Date. ____. |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | 5) <input type="checkbox"/> Notice of Informal Patent Application (PTO-152) |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08)
Paper No(s)/Mail Date <u>8-26-3, 8-30-4.</u> | 6) <input type="checkbox"/> Other: ____. |

DETAILED ACTION***Claim Rejections - 35 USC, § 103***

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(a) and potential 35 U.S.C. 102(f) or (g) prior art under 35 U.S.C. 103(a).

2. Claims 9-13 and 19-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang et al. (USPN 5028565, hereinafter "Chang") in view of Klaus et al.'s "Atomically controlled growth of tungsten and tungsten nitride using sequential surface reactions" (hereinafter "Klaus").

Referring to the Fig. and related text, Chang discloses [Re claims 9-10 and 13] a method of forming a tungsten nucleation layer on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate by contacting the semiconductor substrate with tungsten-containing gas and a reducing agent in the presence of nitrogen; and (b) depositing a tungsten bulk layer on the tungsten nucleation layer by a CVD process in which the semiconductor substrate is exposed to nitrogen; wherein (b) comprises exposing the semiconductor substrate to a tungsten-containing gas selected from the group consisting of WF₆ and W(CO)₆ and combinations thereof (See col. 4, line 49-col. 5, line 68). But it fails to disclose expressly the use of alternating pulses of reactant gases; wherein (a)

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composes performing PNL by alternating exposure of the semiconductor substrate to the tungsten-containing gas and the reducing agent. However, the missing limitation is well known in the art because Klaus discloses these features (See pages 480 and 482). A person of ordinary skill is motivated to modify Chang with Klaus to obtain smooth nucleation layer with low impurity (see Abstract).

[Re claims 11-12] Chang also discloses wherein the nitrogen employed in (a) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate and wherein the nitrogen employed in (b) comprises between about 1 and 20% by volume of the total gas flow to the semiconductor substrate (see col. 5, lines 8-19).

[Re claims 19-24, and 35] The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate in a reaction chamber, the method comprising: (a) forming a reducing layer on the semiconductor substrate; (b) contacting the reducing layer with a tungsten-containing gas to thereby reduce the tungsten-containing gas to a tungsten layer on the semiconductor substrate; (c) contacting the semiconductor substrate with a reducing agent to form a layer of reducing agent; and (d) contacting the layer of reducing agent with the tungsten-containing gas to thereby reduce the tungsten-containing gas to another tungsten layer on the semiconductor substrate; heating the semiconductor substrate to a temperature of between about 200 and 400C and contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the vapor phase comprises a nitrogen carrier gas in addition to the borane compound; purging the reaction chamber of the reducing compound after contacting the semiconductor substrate with the reducing compound in the vapor phase; wherein the tungsten-containing gas of (b) and (d) has the same composition; wherein the tungsten-containing gas of (b) comprises WF₆; wherein the layer of reducing agent formed in (c) is a self-limiting layer; wherein the layer of reducing agent formed in (c) is a silane; repeating (c) and (d) for at least one cycle; exposing the semiconductor substrate to a pulse of WF₆ prior to (a), as shown above. But it does not disclose that the reducing agent is a borane compound, diborane. However, the examiner takes Official Notice, it is well known in the art that diborane and silane are equivalently used as reducing agent.

[Re claims 25, 28, 33-34] The combined teaching of Klaus and Chang does not disclose expressly the claimed duration of exposure to reactants and wherein the duration of contacting

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with the tungsten- containing gas in an earlier cycle is shorter than the duration of contacting with the tungsten- containing gas in a later cycle; and wherein the duration of contacting with the tungsten- containing gas in (b) is shorter than the duration of contacting with the tungsten- containing gas in (d). However, it would have been obvious to an ordinary artisan to do so to obtain an appropriate amount of reactants for each cycle and to prevent corrosion of underlying layer from HF, a reaction product.

Therefore, it would have been obvious to combine Chang with Klaus to obtain the invention as specified in claims 9-13 and 19-35.

3. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang in view of Klaus and Sukharev et al. (USPN 5804249, hereinafter "Sukharev").

The combined teaching of Klaus and Chang discloses a method of forming a tungsten film on a semiconductor substrate, the method comprising: (a) depositing a tungsten nucleation layer on the semiconductor substrate; (b) depositing a tungsten bulk layer on the nucleation layer using a chemical vapor deposition (CVD) process; wherein (a) comprises: positioning the semiconductor substrate in a reaction chamber; heating the semiconductor substrate; and performing PNL on the semiconductor substrate using a tungsten-containing gas and a reducing gas; wherein the reducing agent is a silane; wherein (b) comprises exposing the semiconductor substrate to a process gas comprising one or more of the following: WF₆-H₂, WF₆-B₂H₆, and W(CO)₆; wherein the PNL comprises: (i) flowing a reducing gas into a deposition chamber holding the semiconductor substrate, whereby the reducing gas is adsorbed onto said semiconductor substrate; (ii) purging the reducing gas from the deposition chamber; (iii) flowing a tungsten-containing gas into said deposition chamber, whereby said deposited reducing gas is substantially reduced to a tungsten film; (iv) purging the tungsten-containing gas from the deposition chamber; and (v) repeating (i) through (iv) for one or more additional cycles; wherein the reducing gas is a silane, as shown above.

But it fails to disclose expressly depositing a tungsten cap layer on the tungsten bulk layer using a pulsed nucleation layer (PNL) deposition technique; and repeating (b) and (c) many times.

However, the missing limitations are well known in the art because Sukharev discloses depositing more than one bulk layer and repeat the deposition of bulk layers many times (See Summary).

A person of ordinary skill is motivated to modify Klaus and Chang with Sukharev to appropriately adjust the deposition of W layers and optimize the smoothness of the W layers ensuring thickness uniformity.

Therefore, it would have been obvious to combine Klaus and Chang with Sukharev to obtain the invention as specified in claims 1-8 .

4. Claims 14-18 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chang in view of Klaus, as applied above, and further in view of Berenbaum et al. (USPN 6066366, hereinafter "Berenbaum").

The combined teaching of Chang and Klaus discloses substantially the limitations of claims 14-18, as shown above.

But it fails to disclose expressly the timing of the nitrogen exposure.

However, the missing limitation is well known in the art because Berenbaum discloses this feature (See col. 5, line 31-col. 6, line25).

A person of ordinary skill is motivated to modify Chang and Klaus with Berenbaum to optimize the use of nitrogen in the deposition of W.

Therefore, it would have been obvious to combine Chang and Klaus with Berenbaum to obtain the invention as specified in claims 14-18.

Conclusion

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ha T. Nguyen whose telephone number is (571) 272-1678. The examiner can normally be reached on Monday-Friday from 8:30AM to 6:00PM, except the first Friday of each bi-week. The telephone number for Wednesday is (703) 560-0528.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Michael S. Lebentritt, can be reached on (571) 272-1873. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

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Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).



Ha Nguyen

Primary Examiner

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